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ABSTRACT

A computer-assisted instructional module to teach educable mentally retarded students the survival skill of making change was developed in a two-year project at the University of Texas at Austin. Behavioral objectives were determined through consultation with various interested personnel, including the staff of the Vocational Training Annex at the Austin State School and the staff of the Mary Lee School of Special Education. After determining subskills by task analysis, it was determined that the ability to identify the denominations cf coins and to know the proper value of each was a necessary minimal entering behavior. The IBM 1500-1800 computer system was chosen for its reliability and sophisticated terminals. A metal overlay keyboard was designed containing ten oversize keys; this allowed actual coins to be placed on the keys. Thirty-eight subjects were used, ranging in age from 12 to 30 and in IQ from 45 to 80; 21 students completed all parts of the course. Every student who completed the course improved his score from pre- to posttest, and retention appeared to be substantial. Student responses were studied as the basis fcr future revisions. CAI can be used successfully with the mentally retarded student; the question remaining is whether time and money should be invested in this approach. (MF)

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COMPUTER ASSISTED INSTRUCTION
FOR
VOCATIONAL REHABILITATION OF THE MENTALLY RETARDED

Jack M. Knutson
Robert R. Prochnow

Monograph 2

THE UNIVERSITY OF TEXAS AT AUSTIN
COLLEGE OF EDUCATION
REHABILITATION RESEARCH AND TRAINING CENTER IN MENTAL RETARDATION

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COMPUTER ASSISTED INSTRUCTION

FOR

VOCATIONAL REHABILITATION OF THE MENTALLY RETARDED

by

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and

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Monograph 2

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REHABILITATION RESEARCH AND TRAINING CENTER IN MENTAL RETARDATION

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TABLE OF CONTENTS

Page

I. Introduction..... 1

II. Background of Problem..... 3

III. Computer Assisted Instruction..... 9

Course Development..... 12

Producing a CAI Program..... 20

Developmental Testing on a CAI System..... 22

Pretest..... 28

Administering the Instructional Materials..... 28

IV. Results..... 31

V. Discussion of Results..... 34

VI. Revisions Following On-Line Testing..... 35

VII. Conclusion and Implications for the Future..... 37

Appendix A

I. Introduction

The following report describes in detail the conception, development and results of a project initiated by the Rehabilitation Research and Training Center in Mental Retardation in collaboration with the Computer Assisted Instruction Laboratory at the University of Texas at Austin (CAI Laboratory).

The original problem which stimulated this joint effort is relatively simple to state: i.e. could an instructional program designed specifically to teach a mentally retarded student a set of useful, generalizable skills be presented using a computer assisted instruction (CAI) system? And if so, would it do an effective job at such instructing?

The staff of the two groups have labored almost two years in attempting to answer this question and feel that the results of their experience provide valuable information for any persons interested in the application of technology to the area of rehabilitation training for the mentally retarded. Most of the evidence accumulated indicates that this project was a successful beginning of what will undoubtedly prove to be a long, arduous and expensive task. Whether or not these and similar projects are "worth" the time and effort they cost is a value judgment difficult to render. Certainly, in our present ordering of needs and priorities, it would appear that the emphasis and major expenditures must be devoted to problems where there are obvious, immediate and hopefully inexpensive outcomes. However, if we ever arrive at that happy state where we have the resources and patience to focus some of our attention on long-range programs with high potential, we may decide that CAI can make a substantial contribution to the education and rehabilitation of our young people.

Because the use of computers in rehabilitation and education is new and exotic, there are some who would promote a rapid, undiscriminate

implementation of this technology as a panacea for all our educational ills. This foolhardy and naive advocacy has already served to disillusion and alienate many thoughtful people. This report will provide small comfort for those would spend their time proseletyzing for any single cure to a complex problem. Many difficult problems must be studied and resolved before the promise of CAI in education can be realized. Hopefully, the evidence reported in this volume will be useful to those who continue the search in these areas.

II. Background of The Problem

Programs designed to develop newly-recognized potentials for productive living among mentally retarded persons have flourished under new federal impetus.[1] Laws supportive of these renewed efforts, particularly PL 88-156 and PL 88-164, have been enacted by the Congress in an effort to bolster rehabilitation services to this population.[2] Vocational rehabilitation has been in the forefront of these activities.

Vocational rehabilitation counselors with special training deal with mentally retarded men and women in a wide variety of settings, including Goodwill Industry programs, half-way houses, sheltered and semi-sheltered employment stations, career opportunity centers, State and private schools for the retarded, and pre-vocational and vocational settings within large and small business enterprises.

In addition to these efforts, Vocational Rehabilitation personnel cooperate under inter-agency contract with special education divisions to provide services to students at the educable mentally retarded (EMR) level. A joint program, in operation in Texas since February of 1962, was initiated by the departments of Vocational Rehabilitation and Special Education of the Texas Central Education Agency. Under this joint venture, special education students participate in Vocational Rehabilitation and school programs at the same time. The student is served by Vocational Rehabilitation during a stage critical to job skill development. Vocational Rehabilitation services will be available to a large school-age population in the near future.

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[1]Begab, Michael J. The Effect of Differences in Curricula and Experiences on Social Work Student Attitudes and Knowledge about Mental Retardation. U.S. Department of Health, Education and Welfare, 1968. GPO 868-024.

[2]U.S. Department of Health, Education and Welfare, Programs for the Handicapped, November 21, 1967, 67-18, 7.

U.S. Department of Health, Education and Welfare statistics indicate that almost 400,000 mentally retarded students are being served by the nation's public schools.[3] In Texas, during school year 1968-69, 232 school districts in 124 counties are operating IMR secondary units serving 9,912 students. Cooperative programs utilizing Vocational Rehabilitation services are operative in the great majority of these units, and many new units await only location of appropriate personnel. Elementary and secondary EMR students in Texas number more than 35,000.[4]

The mentally retarded student is usually referred to the offices of Vocational Rehabilitation before his sixteenth birthday for initial interview, counseling, and case documentation by the Vocational Rehabilitation Counselor. A Vocational Rehabilitation plan is developed, which usually calls for pre-vocational and vocational training, personal and social adjustment training, placement, and follow-up services. This plan requires constant updating of information--evaluation, appraisal, and measurement of levels of performance at any given stage of development--to assess the student readiness for each phase of the rehabilitation process. For instance, the Guidelines for Program Development[5] list entering behaviors for each step of development through the Special Education sequence of training. Successful movement from one phase to another demands a reappraisal of skills at each level or phase--an expensive and time-consuming process. There are no guarantees that behavioral

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[3]Mackie, R. P., and Hunter, P. P. Special Education Enrollments and Number of Teachers. Bureau of Educational Research and Development, U.S. Department of Health, Education and Welfare, 1965.

[4]Special Education--Secondary EMR Unit Allocation--School Year 1968-69, Texas Education Agency, Division of Special Education, 1969.

[5]Guidelines for Program Development; Sp. Ed. Vol. I. Texas Education Agency, Austin, Texas, Bulletin 673, 1968.

skills established at one step will be present when more advanced steps are achieved, although the acquisition and retention of such skills are central to the success of the rehabilitation effort. The skills are often difficult to describe, much less measure and teach, and the lack of skilled personnel, along with prohibitive tutorial costs, makes constant feedback a seemingly impossible task.[6] [7]

Vocational Rehabilitation agencies in many states are now operating programs on state school campuses. These efforts are relatively new and still in initial stages of development, but it is anticipated that the rehabilitation of institutionalized mentally retarded persons will require considerable effort and expense.

Among the greatest challenges to Vocational Rehabilitation is the development of innovative programs and techniques to deal with mentally retarded persons with economically disadvantaged backgrounds.

Limited alternatives, feelings of helplessness and insecurity, and general conditions of deprivation among the poor[8] will require extensive utilization and evaluation of special training methods. The motivational component in instructional materials relevant to Vocational Rehabilitation training will become increasingly important. Successful vocational rehabilitation of this group can help alleviate the current manpower shortages in addition to

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[6]U.S. Department of Health, Education and Welfare. Programs for the Handicapped, November 21, 1967, 67-18, 7.

[7]Mackie, R.P., Williams, H., and Dunn, L.M. "Teachers of Children Who are Mentally Retarded," U.S. Office of Education, 1957.

[8]Irelan, Lola M. (Ed.) Low Income Life Styles. U.S. Government Printing Office, U.S. Department of Health, Education and Welfare, 1968.

providing great and obvious benefits to the individual's personal well being.

Present Costs

Over 7,000 successful rehabilitation closures were reported by the Texas Education Agency, Division of Vocational Rehabilitation, in fiscal 1967-68.[9] The average cost for case services for each successfully rehabilitated client was $650.00. The cost of rehabilitation must be compiled from many sources, few of which are amenable to per-student cost determination. Special Education classes are characteristically much smaller than classes for normal students. The Texas State Plan provides for a minimum of eight students for the first unit, fourteen for the second unit, and ten for each additional unit. The most common class size is approximately twelve, somewhat less than one-half the number of students in a normal classroom. This size difference, coupled with the incentive pay provided by most Texas independent school districts, places the teacher salary cost of educating a mentally retarded student at more than twice that of educating the normal student. Costs of materials naturally run higher than for normal classes, and the expense of diagnostic services provided by the schools, though certainly high, is difficult to estimate meaningfully. In addition, the Vocational Adjustment Coordinator, who works with secondary special educational students as a resource person, represents another expense. Educable mentally retarded students are eligible for school services up to the age of 21, adding additional years of

[9] Texas Education Agency, Division of Vocational Rehabilitation--Report to the Legislature on Fiscal 1967-68.

service to the total per-student educational cost. Such evidence as this indicates that the possibility of developing more efficient training and rehabilitating methods would yield not only the obvious educational benefits of quicker and more effective learning, but hopefully would offer long-term economy, even though initial investigative and developmental costs may be high.

Recent Research

Relevant to the issue of developing better instructional techniques, during the past few years the use of programmed and automated instruction has been explored with mentally retarded subjects, and a review of the literature by Prehm and Crosson indicates a successful beginning. They note that Johnson demonstrated that a combination of programmed and teacher instruction was superior to teacher instruction alone in developing addition and subtraction skills with an EMR population. Successful special-purpose curricular innovations involving programmed instructions were evaluated by Corter and McKinney, who found that the effects of training with programmed instruction appeared to generalize to other abilities. In the area of vocational instruction, Knaus found that the automated method is the most efficient of three programmed instructional methods when speed is critical, but that an integrated approach--programmed instruction plus automated methods--is more effective with work sample tasks.[10]

Williams, Gilmore and Malpass, considering the effectiveness of programmed instruction with culturally deprived slow-learning children, cite several studies which suggest that programmed

[10]Cf. Herbert J. Prehm and James E. Crosson, "The Mentally Retarded," Review of Educational Research, Vol. XXXIX, No. 1, February, 1969, pp. 5-24.

instruction can overcome some disadvantages of traditional classroom teaching methods. Teaching machines were found to stimulate attention and interest in learning materials, and contributed to higher performance in word acquisition and arithmetic and reading skills when used with mentally retarded children.[11]

Summary

Teaching educable mentally retarded students certain of the skills necessary for survival and success throughout the rehabilitation process proves to be extremely difficult. While the generalization that mentally retarded students have both a learning and a retention deficit when compared to normal students is evident, it is also true that there is considerably greater variability among mentally retarded students than among normal students. Often the teaching of simple tasks requires the full attention of a counselor for an extended period of time primarily because present diagnostic, instructional, and evaluative procedures must be conducted on a one-to-one basis to be effective.

A review of recent research literature has indicated that programmed and automated instruction may prove to be an effective and efficient method for attacking these problems and has yielded suggestions having important implications for the development of instructional materials to be used in rehabilitation training for the mentally retarded.

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[11] Cf. Charles F. Williams, Alden S. Gilmore, and Leslie F. Malpass, "Programmed Instruction for Culturally Deprived Slow-Learning Children," The Journal of Special Education, Vol. II, No. 4, Summer-Fall, 1968, pp. 421-428.

III. Computer-Assisted Instruction

Utilizing computer power to assist with instruction is one of the most promising new technological developments in education. The computer's memory capacity enables storage of test items and instructional material sufficient to diagnose and instruct a wide variety of students in several content areas. Teams of experienced specialists specify instructional objectives and plan instructional strategies and materials for teaching the specified behaviors to youngsters possessing various skills and abilities. Students receive computer-assisted instruction (CAI) at any one of several terminals operating simultaneously. A typical terminal will consist of a typewriter, an image projector, and an audio unit. These components, all under program control, enable flexible, multi-sensory presentation of material and allow varieties of student responses. The computer maintains a detailed response record for each student, and the interaction of this record with the overall instructional design specifications creates a unique sequence of diagnosis and instruction for each student. In short, CAI provides an exciting new approach for individualizing diagnosis, instruction, and evaluation.

The flexibility inherent in CAI offers many advantages over standard programmed instruction. For example, many mentally retarded students are handicapped by poor reading abilities, and while the effectiveness of most standard programmed instruction is dependent upon the student's ability to read, CAI can partially overcome this difficulty through a multi-sensory presentation of instructional materials.

Most programmed instruction is linear in design; i.e., all students proceed through the same sequence of instructional material. Certain programs, however, are designed to provide extra practice for students experiencing difficulty. The decision as to whether or not a given student has extra practice is usually dependent upon his response to one or two test items. In contrast, CAI can be programmed so that each student's cumulative response record will determine not only whether or not he needs more practice, but also which one of several skills he should learn next and which type of presentation of instructional material will be most effective for him.

All programmed instruction, including CAI, provides some sort of immediate feedback for each student response. However, in standard programmed instruction the feedback usually consists of no more than telling the student the correct answer. CAI feedback can be highly diversified and appropriate to the individual student response. With CAI, if the student's response is incorrect, he is usually given additional information or help so that he will eventually be able to come up with the correct answer himself. The capability of providing immediate, individualized feedback for the student may be particularly important when dealing with the EMR learner who is in need of strong support, attention, and encouragement through each step of instruction.

When it comes to evaluating the student's performance, programmed instruction does not afford easy access to vital information because the responses are written or marked in individual booklets, forcing the counselor to go through each booklet item by item. With CAI,

all student responses are automatically recorded on magnetic tape and are readily available for evaluation. A counselor can quickly determine various students' progress and identify problem areas requiring personal attention.

At the same time, this information can also be used in the continual process of revising and strengthening the instructional program as it is being developed and tested with students.

Another advantage of CAI is the possibility of designing a program which utilizes visual and audio material to simulate a real-life situation. In such a program, the student interacts with the computer and an instructional program which is structured to simulate a concrete realistic situation or problem. The flow of information presented and the resolution of the problem will vary, depending on the student's responses. In each case, however, the student will be developing a skill in an environment designed to resemble those situations he will encounter on the job. This capability may be especially important when dealing with mentally retarded students who have difficulty generalizing from abstract teaching situations and using their newly learned skills in an environment on the job out in the community.

This review of the additional capabilities of CAI indicates that it should be even more effective than standard programmed instruction in meeting some of the problems of educating and rehabilitating the mentally retarded. Teachers, counselors, and others active in Texas' Work-Study program have noted that students in the program often have difficulty acquiring non-academic "survival" skills such as safety behavior, how to use public transportation,

how to tell time and make change, or how to plan a budget. As will be amplified later, the main goal of this project was to develop and test a CAI program for teaching one of these skills to EMR's.

In summary, available evidence indicates that in spite of large expenditures of funds and the concerted efforts of hundreds of devoted specialists, the problems involved in rehabilitating and educating the mentally retarded child to become an employable, productive member of our society are far from being solved. The need for more well-designed and tested instructional material is immediately apparent to anyone who has examined the currently available resources in this area. Among the many potentially valuable new approaches to this old problem, the use of CAI to help train the mentally retarded youngster as he prepares to enter the job market would seem to offer great promise. Therefore the Rehabilitation Research and Training Center in Mental Retardation and the CAI Laboratory at The University of Texas at Austin combined their resources in developing an instructional module for use in pre-vocational training of the mentally retarded student. The principal objective of this project was to develop, test, revise and validate a series of instructional sequences and diagnostic procedures using CAI. The specific steps, procedures and objectives used in this project are explained in detail in the following sections.

Course Development

As the first step in developing a CAI program to meet this goal a set of specific survival skills which this target population needs to learn were determined through consultation with various interested personnel—the staff of the Vocational Training Annex

at The Austin State School, the staff of the Mary Lee School of Special Education, representatives of Goodwill Industries of San Antonio, Vocational Rehabilitation Counselors, and experienced personnel now associated with the Rehabilitation Research and Training Center for Mental Retardation--and in accordance with the Texas Education Agency Guidelines, insuring that the instructional objectives reflected the actual student needs. The original objectives developed encompassed seven major areas, with specific behavioral objectives within each area. A listing of these objectives is presented in Table 1. Examination of these objectives will show that not all of the objectives are equally necessary or applicable at the same time for all students. Although individual student needs will vary, certain of the skills are most appropriately taught at different stages in the rehabilitation process. Before leaving the special education classroom and entering pre-vocational training, the student should have acquired such skills as making change, using the transportation system, and performing general safety behaviors. Before entering the vocational training phase, he should have been taught specific job safety skills, correct use of a time clock, and the appropriate entering vocabulary specific to his training. The on-the-job setting requires still another set of skills, e.g., budget preparation, check cashing, and a set of emergency responses necessary for functioning independently. Given effective CAI modules for teaching specific skills, the teaching of these skills could be scheduled appropriately and without undue inconvenience to skilled personnel. Further, the degree of learning and retention of these skills could be assessed through the diagnostic capabilities of the system.

TABLE 1

Behavioral Objectives of CAI Modules for the Vocational Rehabilitation of the Mentally Retarded

Money Management

The student will be able to:

- Make change accurately
- Determine if change received is correct
- Prepare a budget -- weekly, monthly--which fits a given income
- Determine the effect of advances on future pay checks
- Determine the cost of time payments
- Demonstrate the procedure for buying large items ahead of time using monthly payments and determine final payment date.
- Cash checks (personal and pay) asking for bills no larger than $10.
- Use a checking account, maintaining an accurate balance and using the monthly statement as a validation.
- Determine the cost of a checking account.
- Use a savings account - take bank book when depositing or withdrawing.
- Use deposit slips
- Add sales tax when planning purchases
- Prepare a shopping list

Time Management

The student will be able to:

- Perform unit conversions: hours to minutes, days to hours, etc.
- Tell time accurately to the nearest minute.
- Perform addition and subtraction of time -- hours, minutes, a.m., p.m. -- accurately.
- Prepare a schedule, given amount of time needed for tasks
  a. bed time
  b. leisure time activities
  c. rising time in order to get to work
  d. other items
- Interpret schedules accurately -- month, day, hour, minute.
- Match tasks to time available.

Travel

The student will be able to:

- Locate a street on a map using the street index and the coordinates.
- Determine the direction to given address, given two addresses at present location.
- Describe the action required given a specific traffic sign.
- Use a city map to determine which bus to take, and where to catch it in order to reach a specific location.
- Use VR issued bus tickets correctly.
- Retain return bus fare when shopping or going to a movie.
- Have exact fare when using bus.

Telephone

The student will be able to:
- Determine the phone number of an individual
  - a. in book
  - b. use information
- Identify appropriate firms using the yellow pages.
- Identify correct agency to call in emergency: police, fire, etc.
- Dial weather and time numbers.
- Describe procedure for placing long distance calls
- Ask operator to call a number.
- Demonstrate procedure for calling and asking about a job.
- Call for information on bus schedules, doctor appointment, etc.
- Know important numbers: employer, home, VAC, counselor

Emergency or crisis situations

The student will be able to choose the correct course of action which he should follow in each of the following situations:
- Misses the bus for work.
- Loses a paycheck, wallet, bank book, payment book.
- Financial crisis, big bills, cannot make a payment
- Fired from job or reprimanded severely
- Receives a draft notice.
- Is downtown and has spent bus fare.
- Is ill and cannot work.
- Is out of medicine or needs medical attention.

Job Skills

The student will be able to:
- Identify correct safety behavior.
- Indicate behavior required by warning signs.
- Punch time clock: describe procedure if he forgets to punch in or out
- Ask appropriate questions of appropriate people.
- Follow a series of directions.
- Distinguish concepts of quality and quantity.
- Fill out forms (i.e. applications).
- Know vocabulary important to job skills.

Mailing

The student will be able to:
- Address envelopes and packages correctly.
- Determine amount of postage.
- Identify special items which must be taken to the Post Office (i.e. packages)
- Demonstrate the procedure for mailing packages.
- Send a telegram.
- Send mail special delivery.

The CAI module developed and tested was designed to teach the student to make change from $1 for purchases of less than $1. This particular skill was selected for several reasons: (1) Making change and checking to see that the correct change is received is a function which virtually all non-institutionalized young adults do frequently, (2) consultation with the personnel who work with the retarded in pre-vocational rehabilitation programs indicated that it was a skill in which many of their students were deficient, (3) in comparison with many of the other objectives and needs suggested in the original examination of the problem, the skills and knowledge necessary for making change are relatively restricted both in number and complexity. Thus it was felt that the task analysis necessary in order to construct an instructional sequence to be administered via a computer would be a more manageable undertaking.

The first step in such an analysis is to attempt to break down the desired final skill into component parts. What specific knowledge or sub-skills must the student have if he is going to make change successfully? Probably the first obvious prerequisite is that he be able to identify the denominations of coins and associate the proper value with each one. This skill was, for several reasons, specified as a minimal entering behavior for the instructional module to be developed. This meant that any student who could not display at least some competence in identifying coins when he was first tested was not deemed ready for the materials in the course. (Such an exclusion may appear arbitrary to the reader, but the authors of any instructional materials must begin with some assumptions about the capabilities of their students. Their principal responsibility should be to make these assumptions clear to a potential user of the course.)

Once the minimal entering skills are established, the next job of the course developer is to devise the series of instructional steps which will lead the learner to the final objective. The principal guidelines used in this stage are logical analysis of the task, familiarity with more conventional techniques of teaching the same context and knowledge of the learning difficulties and capabilities of the target population. Using all of this information--plus a lot of insight and intuition --the course developer writes the first draft of his program. This draft, while as complete and thorough as possible, is the first approximation to the finished product. Before it can be considered for programming on the computer, it must be checked out using students similar to those for whom it is intended. This is a time consuming, laborious job, but one that is absolutely essential if you wish to maximize the effectiveness of the final product.

In order to simulate the steps the computer would ultimately go through in teaching the students, it was first necessary to produce the visual and auditory components of the course, not necessarily in their finished form but at least in a mode similar to that to be used by the computer. This meant that dozens of slides, showing various combinations of coins and articles to be purchased, had to be taken. At the same time, it was decided that the standard keyboard display on the computer terminal was unnecessarily complicated for use with the mentally retarded students. Therefore a metal overlay keyboard was designed containing ten oversize keys with easily removable caps. (This latter feature enabled the authors to place actual coins on the keys and to tell the students to "press the coin" worth a certain amount). A mock-up of this keyboard was used in testing the course with the students.

After all of the course material had been written, the pictures taken and assembled, and the simulated keyboard built, two staff members went to various rehabilitation centers to try out the module with students from the target population. Working with each student individually in hour long sessions, the staff functioned as a team. One of the members played the role of the computer asking the same questions, showing the same slides, etc. which would eventually be presented to the student under computer control. The other staff member acted as an observer, recording all pertinent information possible concerning the instruction. Whenever the student did not understand the particular wording of a question, or when an explanation was obviously unclear, this was carefully noted for future course revisions.

It should be emphasized that such a deliberate, extensive testing procedure is of substantial value. Justifications for this rigorous procedure include the following: (1) The basic assumption is that if the instructional material does not work, the fault lies in the material--not the student. The time to revise, change or elaborate is before the product is ready for large scale production. (2) the extensive time spent at this stage working with a few students on a one-to-one basis is time well spent in terms of the overall quality of the final product. What is ultimately important is what the student learns from his contact with the product. (3) The best place to get information about what "works" and what does not is by sitting down with the students and trying various possibilities. Markle suggests a series of approximately ten teacher-student sessions, creating increasingly effective techniques toward the provision of a prototype of the programmed instructional unit being developed.[12] This developmental testing procedure may indicate that there

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[12]Cf. Susan Markle, "Empirical Testing of Programs", P.C. Lange (Ed.) of the National Society for the Study of Education, Chicago: University of Chicago Press, 1967.

is no need for the program or that the specified objectives cannot be achieved economically or effectively. In this event, the program objectives cannot be achieved economically or effectively. In this event, the program objectives can be abandoned or revised accordingly. As was suggested above this developmental testing phase of instructional design does provide valuable data necessary for individualizing the final CAI module, in addition to the opportunity to test materials and equipment.

As a result of this initial tryout phase, extensive revisions and modifications of the materials were made. Many ambiguities in terminology were clarified. Several explanations were amplified, others were eliminated or shortened. Student comments concerning the general approach to the problem were positive; they seemed to enjoy the experience while learning the skills.

After the revisions were completed, the materials were readied in their final form to be programmed for the computer. Up to this point, all of the developmental activities described had been relatively independent of the computer, using human rather than mechanical labor. The next step was to produce the materials in a form which would be usable at a computer instructional terminal. Before this could be done, however, a crucial decision had to be made concerning the computer system to be used. One of the systems available was the IBM 1500-1800 system. Its principal virtue was that it was a system that was extremely reliable and had very sophisticated student instructional terminals. The latter included a cathode ray tube for displaying graphics, a rapid-access image projector which could display up to 1000 different slides, and an audio device which would play hundreds of different messages. Its main drawback was the fact that these terminals had to be connected to the computer with a coaxial cable. This necessitated that all of the terminals had to be located in the CAI Lab

and could not be used at remote locations. The other computer system available was an IBM 360-50 system which used much simpler, less reliable, instructional terminals. It did have the one feature lacking on the other systems, i.e. instructional terminals could be located at remote sites and connected to the computer at the University via standard telephone lines. While this latter capability would be essential in a later phase of wide scale implementation, it was decided that the greater versatility and control obtainable on the IBM 1500/1800 system would outweigh the disadvantages of having to bring students to the CAI Lab for their instruction during this developmental stage.

Producing a CAI Program

The multitudinous problems encountered in the process of producing a CAI program--once it is written as described above--are primarily technical in nature. Therefore, this section of the report will not go into extensive detail, but will describe the nature of some of the problems and how they were solved. For those who might feel inclined to skip over this section, one generalization must be made. The experience of the CAI staff is that the process of taking written instructional materials and going through the necessary steps so that they may be used on a computer is frustratingly slow and tedious. It always seems to take more time and labor than even the most pessimistic had anticipated. There are several reasons for this. (1) The process of coding the materials into a computer language is a task which must be done by trained programmers and often will involve the writing of thousands of symbolic commands. Inevitably many small errors occur and these must all be found, in the "debugging" stage of the project. (2) Since CAI is a new technology, much of the terminal equipment is still in a developmental state. This means that unexpected

hardware failures are common and often difficult to pinpoint. (3) The innovative quality of the work being done minimizes the extent to which one can rely on experience or expertise from others in the field. Often the only way to see if something works is to try it, find out that it does not, and then try something else.

Two major problems slowed the production of the change making module, and both were technical problems which had been completely unanticipated. The first had to do with the difficulty of photographing color pictures of coins so that the picture displayed on the image projector would be clear. Even though such a problem may seem trivial in comparison to the total project, it represents the type of frustrating annoyances which arise and play havoc with production schedules.

The other technical difficulty which caused considerable problems was the audio system. This component of the instructional system had just been developed by IBM and the CAI Lab had one of the first available production models. Not only had the staff not had previous experience with this particular component, it also turned out that there was an intermittent electrical flaw in the circuitry which caused numerous "unexplainable" breakdowns and mistakes in the entire system.

Both of these relatively "minor" problems are being mentioned because they are typical examples of the type of trouble which arise whenever a new technology is being developed. Most of them are probably unavoidable and necessary hazards to be overcome. They are, however, exceedingly discouraging in terms of the time their solution takes and also in the amount of money which they cost. (Those individuals who are or are planning to engage in the technical production of CAI and would like more detail concerning the solution to these and similar problems may write to the CAI Laboratory).

In brief, often several months of programming, producing audio tapes and pictures and integrating these into a running program, an instructional program to teach change making was finally ready to be tested on a sample of the target population. The procedures used will be described in detail in the next section.

An extensive example of the contents of this change making module and the kind of instructional sequences the typical student went through are found in Appendix A.

Developmental Testing on a CAI System

Subjects. The students used in testing the CAI version of the change making module had to meet two minimum criteria. (1) They were identified mental retardates either in special classes in the public schools or in some sort of "sheltered" environment set up to assist in the rehabilitation process. (2) They had to be willing and able to come to the CAI Lab for several short instructional sessions at the computer terminal. Because of this latter restriction, the staff was unable to use a large number of pupils from the Austin Public Schools. Those pupils who did participate in the study are described below along with a brief description of the institution in which they were found.

Del Valle Independent School District. This district operates several regular schools in an area adjacent to Austin. Among these is a separate facility devoted to special education. After a discussion between the CAI Lab staff and the Director of Counseling and Special Education, the latter with the assistance of the Vocational Counselor selected those students from the school whom they believed might be eligible for and benefit from the course. This group contained 15 girls and 13 boys ranging from 12 to 18 years of age and having IQ's ranging from 45 to 75. Eleven of these

students, 8 girls and 8 boys, were native Spanish speakers. Of these 28 students who took the pretest, 3 did not meet the minimal requirement (identify coins) for taking the course, and 5 could already perform the tasks which the course is designed to teach. Thus, 20 students were selected to take the course from this group. The demographic and pretest scores for all 28 students is found in Table 2.

Mary Lee School. The Mary Lee School of Special Education is a halfway house for female retardates. Its purpose is to prepare retardates for an independent, self-supporting existence. The staff of the Mary Lee School identified 18 students for initial testing. Of these 18, two were not able to identify coins, 7 could already perform the skills which the course was designed to teach, and 9 were selected to take the course. Detailed demographic and pretest data for the Mary Lee students is presented in Table 3.

Career and Guidance Center. The Career and Guidance Center of Austin is a halfway house for male retardates, and it also has as its purpose preparing retardates for an independent, self-supporting existence. The director of the Center selected 9 students whom he felt would probably be eligible for the course. One of these could not identify coins, and eight were selected to take the course. Detailed data on these students is presented in Table 4.

TABLE 2. DEMOGRAPHIC AND PRETEST DATA FOR DEL VALLE STUDENTS

Student	Sex	Age	I.Q.	Pretest Max=19	Transfer Max=6	Decision*
VV21	F	15	63	6	3	1
VV02	M	13	67	0	1	2
VV03	M	15	51	11	2	1
VV04	F	13	64	0	0	1
VV05	F	13	75	8	4	1
VV06	F	13	57	3	2	1
VV07	F	12	45	1	0	1
VV08	F	13	63	1	0	1
VV09	F	13	75	11	6	1
VV10	F	15	64	5	0	1
VV11	M	14	75	5	0	1
VV30	M	12	56	2	0	1
VV12	F	13	73	6	2	1
VV13	M	12	70	12	1	1
VV15	F	15	68	8	4	1
VV16	M	12	71	3	0	1
VV17	M	12	70	2	1	1
VV18	F	14	70	7	0	1
VV14	M	18	51	6	0	1
VV19	F	16	68	10	4	1
VV20	M	12	56	2	0	1
VV42	F	14	60	0	0	2
VV43	M	12	56	1	1	2
VV32	F	14	72	13	5	3
VV40	M	17	60	14	5	3

TABLE 2 continued

Student	Sex	Age	I.Q.	Pretest Max=19	Transfer Max=6	Decision*
VV41	M	15	75	11	6	3
VV44	M	14	72	12	5	3
VV45	F	16	55	12	6	3

*1 = student should take course
2 = student does not meet prerequisite
3 = student already possesses skills

TABLE 3. DEMOGRAPHIC DATA FOR MARY LEE STUDENTS

Students	Age	I.Q.	Criterion Measure Max=19	Transfer Max=6	*Decision
ML01	20	78	9	3	1
ML02	22	76	10	1	1
ML03	22	52	1	1	1
ML05	20	80	6	3	1
ML06	18	80	6	3	1
ML07	27	69	2	1	1
ML08	17	73	7	3	1
ML09	27	69	5	0	1
ML10	23	68	7	1	1
ML11	18	65	0	0	2
ML12	30	31	0	0	2
ML04	22	76	14	5	3
ML13	21	64	14	6	3
ML14	23	81	18	3	3
ML15	17	83	16	6	3
ML16	20	(not available)	17	4	3
ML17	16	70	17	5	3
ML18	18	73	17	6	3

* 1 = student should take course
  2 = student does not meet prerequisites
  3 = student already possesses skills

TABLE 4. DEMOGRAPHIC DATA ON CAREER AND GUIDANCE CENTER STUDENTS

Student	Age	I.Q.	Criterion Measure Max=19	Transfer Max=6	Decision*
WW01	23	58	1	0	1
WW02	18	72	7	2	1
WW03	18	76	12	2	1
WW04	25	53	9	3	1
WW05	21	62	1	1	1
WW09	20	50	1	1	1
WW07	30	56	5	2	1
WW08	28	66	14	4	1
WW10	39	54	1	0	2

* 1 = student should take course
  2 = student does not meet prerequisites

Pretest. The pretest mentioned in the proceeding sections was developed as a screening device to determine if the student possessed the necessary prerequisite skills or if he has already learned the material the course was designed to teach. It was made up of a sub-set of the criterion items from the course materials and was administered verbally by the examiner. Each student was tested individually and responded to questions by pointing to pictures of coins representing the correct answer. There were a total of 19 possible points on the test.

A second test designed to simulate a more realistic situation was also constructed. There the student was instructed to decide whether or not he had received the correct change from the tester who was role playing the part of a store clerk. This test is referred to as the transfer test, since it attempted to see whether or not the student could apply change making skills in a more realistic context. In both of these tests the student was given no feedback as to whether or not his responses were correct. Those students who took the course were given the same tests at the end of their instruction to determine what progress they had made. These results will be examined later.

Administering the Instructional Materials. After the screening procedures described above were completed the students began taking the course. It was anticipated that each student would require from one to three hours to complete the course. It was further intended that eachstudent would work for from ten to twenty minutes during each session at a terminal. Since two student terminals were available for the course, no more than two students could take the course at the same time. Because the Del Valle and Mary Lee students had to be transported several miles to the laboratory, four students were brought in at the same time. Two students

took the course while two others waited. The Del Valle students came to the laboratory during normal school hours (8:30-3:30), while the Mary Lee and Career and Guidance students came when their schedules permitted. Some of the Mary Lee students and all of the Career and Guidance students had full-time jobs at various hours. Thus, students took the course from 9:00 to 11:00 a.m., 1:00 to 4:00, and 6:30 to 9:30 p.m. The Del Valle students spent approximately thirty minutes traveling and fifteen minutes waiting for each fifteen minutes they spent at a terminal taking the course. The Mary Lee students spent somewhat less time traveling. The Career and Guidance students had much fuller schedules, so they took the course in twenty-five to forty-five minute blocks and spent approximately twenty-five minutes walking to and from the laboratory for each visit.

School holidays, illness and other absentism resulted in extremely uneven attendance for the Del Valle students. At one point nearly one-half the Del Valle students, all boys, refused to come to the CAI Laboratory. Questioning revealed that they were being required to attend during their play period and did not want to miss that. Rescheduling solved this problem, but it is a typical example of the many difficulties involved in bringing several students to the laboratory over an extended period of time.

On the first visit to the CAI Lab a staff member explained the necessary items of the student terminal to the student. Each student was shown the volume control on the audio unit. Spanish speaking students were asked if they wanted to begin the course in Spanish or English, but all chose English. The staff member told them that they could change to Spanish at any time by pressing the "L" on the keyboard. She also carried out all sign-on procedures, placed the keyboard overlay on the keyboard, and assisted the student in putting on the audio head set. When students were taking the course, at least two staff people were in attendance so that students

could be monitored and helped readily. The course uses four audio tapes which need to be changed during the course, and the staff assistant was responsible for doing this whenever it needed doing. She also kept a record of each student's progress and of the amount of time each student spent on the course.

Three students came to the laboratory for only one or two sessions and did not return. One other student was arrested and returned to a state school after beginning the course. Two students who had not been selected to take the course joined the group and took part of the course. Thirty-eight students took at least part of the course, and 21 completed all parts of it. The students who completed the course spent an average of 3 hours and 15 minutes on the course, ranging from 1 hour, 40 minutes to 7 hours, 8 minutes. The 5 students who stopped taking the course for any reason spent an average of 56 minutes on the course, ranging from 21 minutes to 1 hour, 40 minutes. The 12 students who were not able to complete the course spent an average of 2 hours and 35 minutes on it, ranging from 1 hour, 5 minutes to 5 hours, 40 minutes.

IV. Results

The complete data for all students who either took the pretests and/or all or part of the course is found in Table 5. The retention scores which are reported there represent the students performance on the criterion test two weeks after he completed his course work. Like the pre- and posttest this was administered individually in a non-computerized form to each student.

Since the number of students who completed all phases of the testing and instruction was small, and since the principal objective of the project was to obtain information leading to further course improvement, statistical analyses run on the data were limited.

Of the 31 students who took the course, 10 did not complete all of the three "review trips" that were part of the instructional sequence. Upon completion of the course, or at the end of the available time, each student took a posttest. These students were also given a retention test after two weeks. Both the posttest and the retention test consisted of one section assessing the specific behaviors taught by the course (criterion measure) and a second simulation section (transfer measure). A t-test revealed that significant ($p. < .01$) gains were made pre- to posttest on the criterion measure. The pretest-to-retention change was also significant ($p. < .05$), but students showed a loss from posttest to retention. On the transfer measure, only the pre-to posttest to retention. On the transfer measure, only the pre- to posttest gain was significant ($p. < .05$). Examination of the data which is complete reveals that every student who completed the course improved his score from the pre- to posttest.

Results of the two week retention test reveal some diminution in scores but most of the students appeared to retain a substantial portion of what they had learned.

Table 5

Change Making Data for All Subjects

Student	Sex	* Int	Age	IQ	Com	Time (mins.) On-line	Criterion Measure *** Pre	Post	Reten	Transfer **** Pre	Post	Reten
ML03	F	1	22	32	1	349	1	5	4	1	1	0
ML05	F	1	20	80	1	142	6	10	9	3	3	1
ML06	F	1	18	80	1	182	6	18	18	3	3	1
ML07	F	1	27	69	1	120	2	14	12	1	4	4
ML08	F	1	17	73	1	387	7	12	8	3	2	1
ML09	F	1	27	69	1	200	5	11	8	0	1	0
ML10	F	1	23	68	1	428	9	8	6	1	1	1
VV21	F	0	15	63	1	152	6	9	7	3	2	3
VV03	M	0	15	51	0	131	11	11	9	2	2	1
VV04	F	0	13	64	1	257	0	6	4	0	2	2
VV05	F	0	13	75	1	114	8	11	9	4	4	3
VV06	F	0	13	57	1	260	3	9	5	2	2	1
VV07	F	0	12	45	0	340	1	5	4	0	0	0
VV08	F	0	13	63	0	282	1	6	5	0	2	2
VV09	F	0	13	75	1	122	11	18	17	6	5	4
VV10	F	0	15	64	1	130	5	15	13	0	3	3
VV11	M	0	14	75	1	209	5	10	9	0	2	2
VV30	M	0	12	56	0	158	2	8	6	0	1	0
VV12	F	0	13	73	1	191	6	10	10	2	4	3
VV15	F	0	15	68	1	240	8	11	9	4	4	3
VV16	M	0	12	71	1	200	3	8	7	0	2	1
VV17	M	0	12	70	1	155	2	7	6	1	2	1
VV18	F	0	14	70	0	190	7	14	10	0	3	1
VV20	M	0	12	56	0	158	2	8	6	0	1	0
WW01	M	2	23	58	0	95	1	5	4	0	0	0
WW03	M	2	18	76	1	130	12	12	12	2	3	2
WW04	M	2	25	53	0	95	9	12	11	3	3	3
WW05	M	2	21	62	1	100	1	7	5	1	3	3
WW09	M	2	20	50	0	130	1	5	4	1	0	1
WW07	M	2	30	56	0	140	5	8	7	2	2	2
WW08	M	2	28	66	1	127	14	17	15	4	5	5

*Del Valle - 0
Mary Lee - 1
Career Guidance - 2

**Complete Course: Yes - 1
No - 0

***Maximum - 19

****Maximum - 6

Table 5 (continued)

Dhange Making Data for All Subjects

Student	Sex	* Int	Age	IQ	** Com	Time (mins.) On-line	*** Criterion Measure Pre	Post	Reten	**** Transfer Pre	Post	Reten
ML01	F	1	20	78	0	50	9			3		
ML02	F	1	22	76	0	33	10			1		
ML04	F	1	22	76	0	000	14			5		
ML11	F	1	18	65	0	000	0			0		
ML12	F	1	30	310	0	000	0			0		
ML13	F	1	21	64	0	000	14			6		
ML14	F	1	23	81	0	000	18			3		
ML15	F	1	17	83	0	000	16			6		
ML16	F	1	20	??	0	000	17			4		
ML17	F	1	16	70	0	000	17			5		
ML18	F	1	18	73	0	000	17			6		
VV02	M	0	13							1		
VV34	F	0	13	61	0	65		4	2			
VV32	F	0	14	72	0	000	13			5		
VV13	M	0	12	70	0	102	12			1		
VV22	F	0	14	74	0	77			13			5
VV14	M	0	18	51	0	000	6			0		
VV19	F	0	16	68	0	000	10			4		
VV40	M	0	17	60	0	000	14			5		
VV41	M	0	15	75	0	000	11			6		
VV42	F	0	14	60	0	000	0			0		
VV43	M	0	12	56	0	000	1			1		
VV44	M	0	14	72	0	000	12			5		
VV45	F	0	16	55	0	000	12			6		
WW02	M	2	18	72	0	78	7			2		
WW10	M	2	39	54	0	000	1			0		

*Del Valle - 0
Mary Lee - 1
Career Guidance - 2

**Complete Course: Yes - 1
No - 0

***Maximum - 19

****Maximum - 6

Naturally, this analysis is exploratory and suggests trends but should not be construed as proving the point, Q.E.D. Much more rigorous research is clearly indicated.

An attempt was made to determine if there was any correlation between the gain scores obtained from the pre- to posttest and the students I.Q. No reliable correlation was evident. Similarly, no correlation was found between the students age and his gain score.

V. Discussion of Results

All of the rather elaborate testing and instruction for these students was conducted with two principal questions in mind. (1) Is CAI a feasible medium to use for the instruction of the mentally retarded? (2) What information can be collected which will contribute to improving the effectiveness of the instructional module?

In regard to the first question as to the potential feasibility of CAI most of the results are encouraging. Without exception, students who completed the course improved their performance, some showing rather substantial gains after only an hour or two of instruction. Moreover, the comments of the students and their eagerness to come to the instructional sessions revealed a positive attitude and enthusiasm for this method of instruction. They learned and they seemed to enjoy it.

On the negative side of the picture, there were several students who seemed to benefit very little from the course--at least as measured by their performance on the tests. Some labored several hours and were able to improve their test scores only a few points. In contrast to the majority of students who voiced pleasure with CAI instruction, there were some who did not like working with a machine and declined to return. Although the reasons for this dislike would have to be determined on an individual basis,

it seems very likely that for some subset of students the impersonality of a mechanical instructor is not desirable.

The low gain scores exhibited by some of the students, while disappointing, was not entirely unexpected. In spite of all the care and revisions which had gone into improving the initial version of the course, the authors expected this second stage to show up further deficiencies and need for modifications. As was mentioned earlier, one of the unique features of CAI as a vehicle for instruction lies in the ability of the computer to collect detailed data which will provide information useful in pinpointing problems in the material. Some of these will be discussed in the next section.

VI. Revisions Following On-Line Testing

In addition to the summary data described above, a detailed item analysis of all student responses was gathered. Every response for every question in the course was classified and studied as a means of locating weaknesses in the logic of the sequences of presentation and possible ambiguities in the wording of instruction. Such information is obviously invaluable to the course developer who wishes to make his instruction more effective. Some of the problems discovered were primarily technical, and can be easily remedied. For example, when students were asked a question and told to respond by pressing a particular key or pointing to a letter on the screen, it was necessary that they wait a second or two until the word "Go" appeared on the cathode ray tube. If they responded before this, their answer was not recognized by the computer and was counted as incorrect. Since many students seemed to respond in this manner, it will be necessary to place more explicit reminders throughout the audio portions of the course.

Another example of the information obtained from the item analysis is more directly related to the learning problems of the retarded student. The first task confronting the student in the course is to identify coins, first by name, and then by value. The groups did much better at naming the coins than they did at associating the proper value with each. Specifically, they did rather poorly at identifying the value of a half dollar. This may, in part, be due to the relative scarcity of these coins in circulation during the past few years. In any case, it would appear that some students would benefit from more practice on this particular skill and that this section of the course should be lengthened.

Another section of the course which apparently needs to be revised is a part in which the student is asked to count a set of coins, beginning with the coin of largest value and proceeding down to that with the smallest. To do this, the student begins by pressing the key with the coin of largest value; when he does this the picture on the projector changes and the original set of coins is shown <u>minus</u> the coin he has pressed. He is then to continue with the next coin, etc. until the entire set is counted. Since many students had trouble with this section, it appears that they did not understand the procedure completely. Perhaps they simply need to be reminded more frequently as to what they are to do; on the other hand, it is quite possible that the procedures here are unnecessarily complicated and unclear and need thorough revision.

A frequent type of error which the students made seemed to involve situations where they were presented with a piece of information over the audio system and then were expected to retain and use this in responding to a subsequent question. For example, the audio might say "Now make believe

that you have been counting money. You have just counted 10 cents and next is the money in the picture. How much altogether?" It may be that this type of problem is difficult simply because the wording is unclear; however, it could be that information presented in two modalities is difficult to process for this type of learner. Future revisions and controlled comparisons should help clarify this issue.

Hopefully, it is apparent to the reader from the preceding examples just how useful a tool the computer can be. The course developer can quickly amass large amounts of data to assist him revising his course to maximize effectiveness. Empirical evidence can be the basis for revision; he no longer has to rely primarily on intuition or luck in locating deficiencies in his instructional sequences. He can systematically go about revising his materials and feel fairly confident that each iteration will produce a more effective product.

Conclusions and Implications for the Future

In its present form the course was apparently effective at improving the change making skills of a large proportion of the students taking it. CAI can be utilized successfully in teaching a set of specified skills to the mentally retarded student. The question which remains unresolved is whether or not more time and money should be invested in this particular approach to the multiplicity of problems facing the professionals in the area of rehabilitation training for the mentally retarded. Time and money are both scarce commodities, and this project provides ample evidence that large amounts of both will be necessary if we are going to make real progress in applying computer technology to the solution of these problems. Examination of the data discussed earlier indicates that extensive, time consuming revisions in the course material would improve its effectiveness.

Such revisions, however, would take several months of work and would cost thousands of dollars.

Extrapolating from these experiences, one would have to hypothesize that an expenditure of millions of dollars would be necessary if one wanted to set about developing instructional modules to meet all of the objectives originally outlined.

At the same time, assuming that such material was developed and tested, the problems of an adequate computer hardware system would have to be faced. As was indicated earlier, it would have been much more desirable if the instructional terminals had been located in the schools and rehabilitation centers rather than in the CAI Laboratory. However, the placement at remote locations of the type of multisensory terminals needed by students with special problems will not be possible for some time--at least not for what most people would regard as a reasonable cost. During this interim period, what activities are likely to promote the rational development of CAI applications to the problems of rehabilitation and the mentally retarded?

It is the considered opinion of the project staff that a systematic, empirically based approach to the design of instructional materials is fundamentally sound, whether one is working with normal students or those with special problems. Given the time and resources, a series of short instructional modules could be developed and tested that would do an effective job at helping students reach pre-specified objectives. It may not, however, be necessary (or even desirable) to use a computer or other elaborate technology during this developmental stage. An alternative procedure could perhaps be devised which would utilize many of the essential features of the developmental cycle described in this report, and at the same time eliminate (for the present at least) the expense and technical problems accompanying CAI. Let us examine how such an apprcach might be implemented.

The steps to be followed would in part be identical to those described earlier in this report. It would still be necessary to define objectives, analyze the components of the tasks leading to the objective, develop a tentative instructional sequence and test it out with the prospective students--just as was done in the development of the change making module. However, the succeeding steps of coding the materials for the computer, producing special pictures, etc. could be eliminated. Instead this time could be used to test the materials with the students, working either on a one-to-one basis or in small groups of two or three. The results of these tests could then be incorporated into a revised, improved version of the original product. While the individualization built into a good CAI course is extremely desirable--particularly for students with special problems--it may be possible that a more conventional "paper and pencil" form of the course could incorporate many of the same features at a considerably lower cost. For instance, the instruction developed for the change making module could be adapted for a kind of tutorial package to be used by a relatively untrained person. This person could, after receiving brief instructions, play the role of the computer, asking the student questions, telling him if he was right, giving him more practice as needed, etc. Since all of the decisions about the exact sequence of instructions and the form it was to take would have been made and tested in the developmental phase, the person who was acting as the tutor would merely have to follow directions patiently Quite possibly volunteers, such as parents and interested high school students, could be trained to adminster the materials, thus offering needed assistance to the regular instructor. Materials developed and used in this manner would presumably incorporate many of the same features found in a CAI version. The crucial difference is that they would use a human "tutor" to carry out the functions of the computer. Assuming that these products

were well constructed and tested, such a tutor would not have to be an expert or even a highly trained person. But until the cost of computer technology is considerably less, he could carry out many of the same functions.

This proposed strategy may have another great virtue. If the materials were designed with the distinct probability in mind that ultimately the computer would take over the tutorial job, then there would be available a sizable collection of good, tested curriculum materials to be used in CAI when lower costs made such action feasible.

In conclusion, it is hoped that many people interested in the development of better instruction and training for rehabilitation of the mentally retarded will attempt to implement some of the ideas outlined in this report.

Most of the project's original objectives and ideas for instructional modules remain undeveloped not for lack of need or merit--but because of limitation in time and staff. If several groups were to each take one or two of these objectives and set about writing and testing instructional packages to meet these goals, in a short time a significant number could be generated and distributed throughout the nation. Such an undertaking would necessitate careful planning and cooperation on a large scale. But the potential payoff in terms of people better equipped to become contributing, self-supporting members of our society would make such an effort well worth the cost.

Appendix A

A Detailed Example of the Logic and Instruction in the Change Making Module

One of the msot important sets of general behaviors which Vocational Rehabilitation clients need to learn is that set necessary for effective money management. Basic to the array of skills and attitudes generally viewed as money management are the skills of counting money, making a small purchase, and checking one's change. An instructional module, entitled the Change Making module, has been designed to teach these skills through a simulated shopping trip. In order to teach them effectively, the exact terminal behavior of the student must be specified. For this module, the behavioral objective is as follows:

In the following situation:

> A customer enters a store, counts his money, selects an item costing less than one dollar, and purchases the item.

The student will be able to:

1. Determine the amount of customer's money
2. Determine if the customer has sufficient money to buy a given item
3. Choose coins to purchase the item
4. Determine if change received is correct

After determining the terminal behavior, the separate skills necessary for accomplishing it are identified. This implies a process of working backward from the final, rather complex, behavior toward a set of separate, and less complex, skills. This process yields a hierarchy of behavioral objectives, at the bottom of which are the necessary entering behaviors, skills which the student must possess before working toward the terminal behavior. The hierarchy

of objectives for the Change Making module is shown in Figure 1. The necessary entering behaviors--labeled I.A, I.B, and I.C--are shown at the very bottom.

Individualizing the Instructional Sequence

Next the instructional setting, the simulated shopping trip, is examined in order to determine the best way to test for and teach each of the behaviors in the hierarchy. A flowchart indicating the overall path which students will follow through the hierarchy is then prepared. The flowchart for the Change Making module is shown in Figure 2. Each objective specified in Figure 1 is referred to in Figure 2 by the appropriate alphanumeric, e.g., I.A, III.B, IV.B.2. The reader should note that in Figure 2 the statements in several boxes imply that the student will go through an instructional sequence of some length. For example, consider the diamond-shaped decision box containing the statement:

III.B
Add value of
coin to given
amount

At this point the student will be tested to find out if he can perform the behavior specified in objective III.B (Figure 1). If he can he will move up within the hierarchy and be tested for the behavior specified in Objective IV.B.4 (Figure 1); if he cannot he will be taught the skills required for the lower-level objective. The detailed steps of each teaching sequence, such as "Teach student to add a coin to given amount," are not shown in Figure 2. These steps are therefore described below in order to provide the reader with an example of the more fully-elaborated flowchart:

Figure 1

Change Making Hierarchy of Objectives

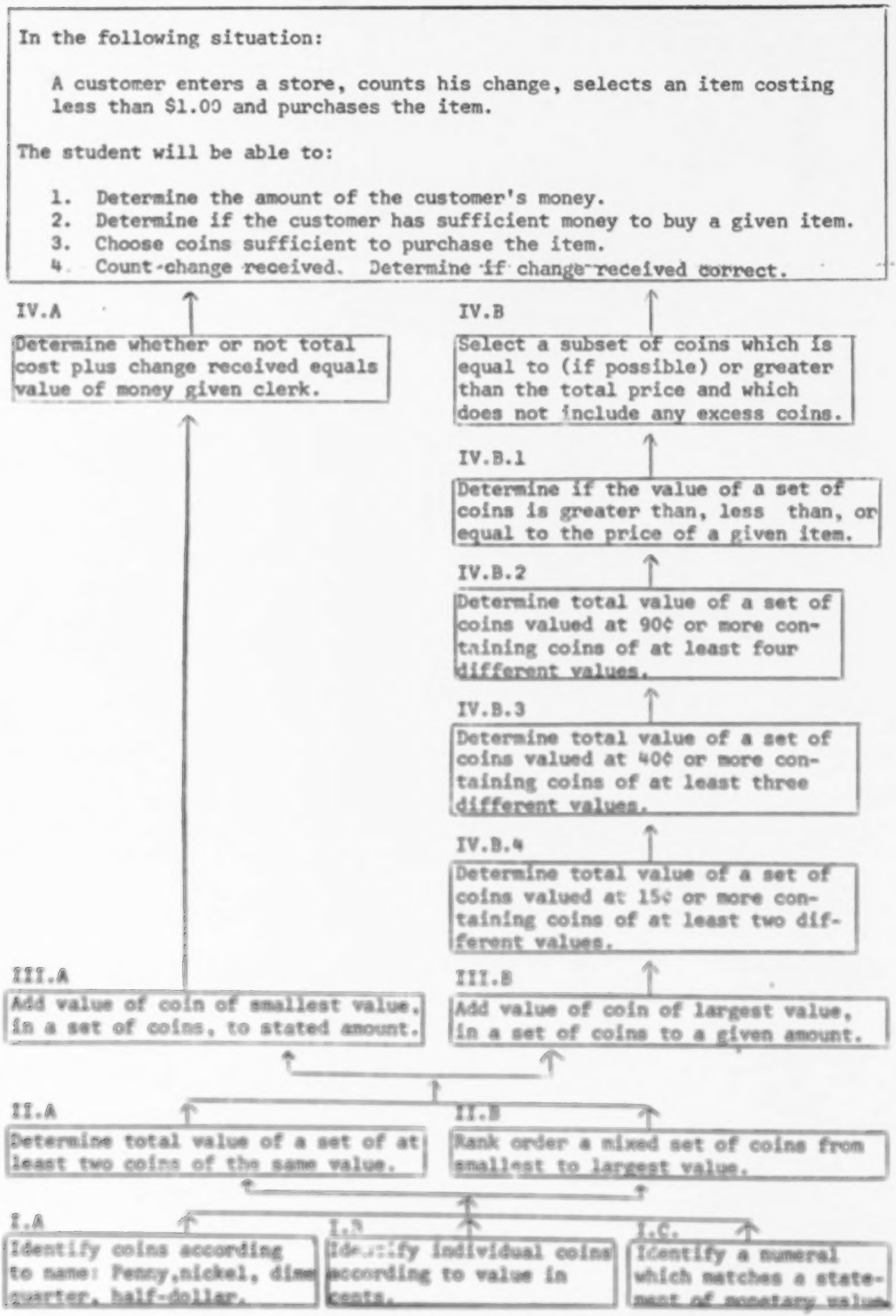
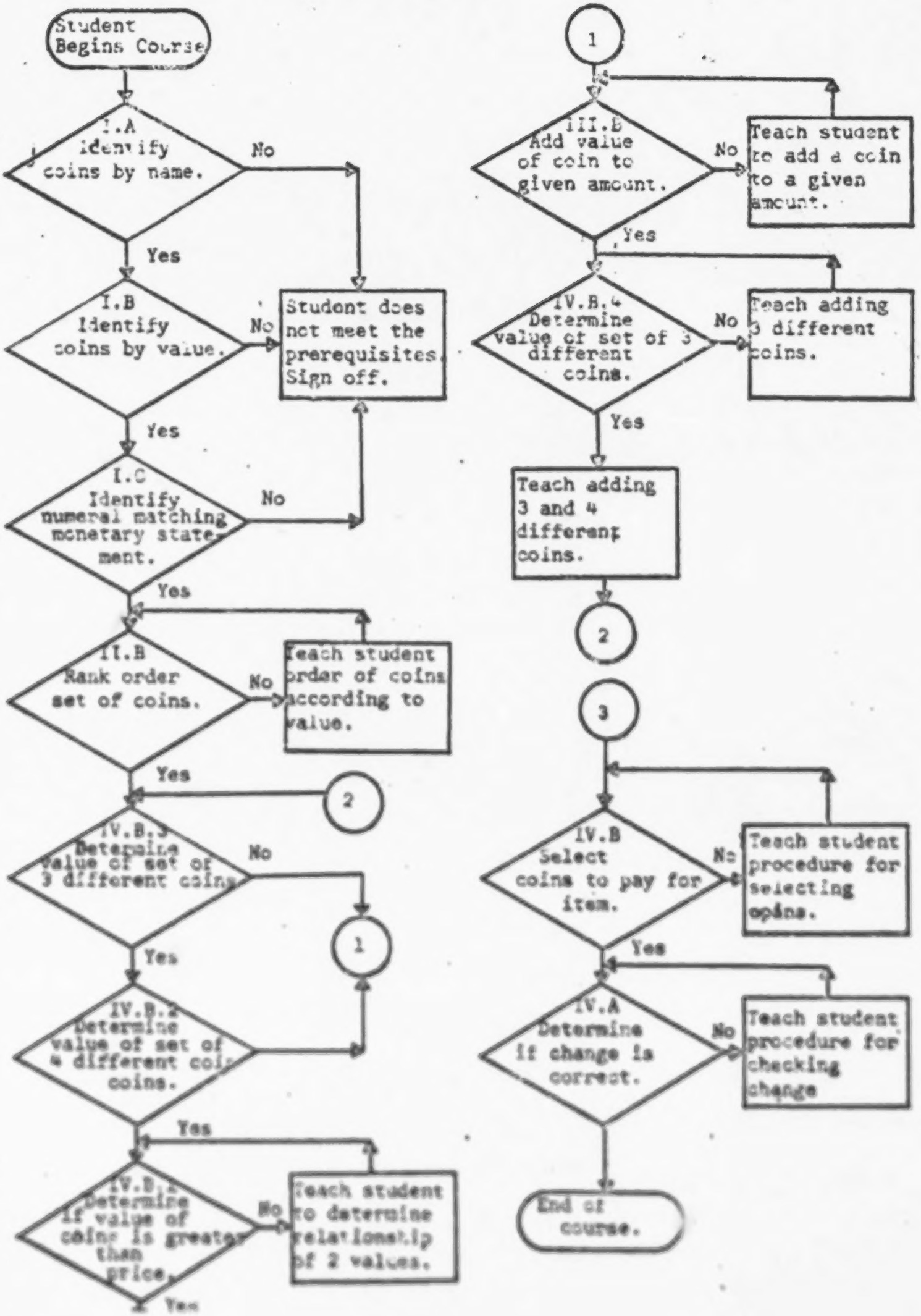

In the following situation:
A customer enters a store, counts his change, selects an item costing less than $1.00 and purchases the item.
The student will be able to:
1. Determine the amount of the customer's money.
2. Determine if the customer has sufficient money to buy a given item.
3. Choose coins sufficient to purchase the item.
4. Count change received. Determine if change received correct.
IV.A
Determine whether or not total cost plus change received equals value of money given clerk.
IV.B
Select a subset of coins which is equal to (if possible) or greater than the total price and which does not include any excess coins.
IV.B.1
Determine if the value of a set of coins is greater than, less than, or equal to the price of a given item.
IV.B.2
Determine total value of a set of coins valued at 90¢ or more containing coins of at least four different values.
IV.B.3
Determine total value of a set of coins valued at 40¢ or more containing coins of at least three different values.
IV.B.4
Determine total value of a set of coins valued at 15¢ or more containing coins of at least two different values.
III.A
Add value of coin of smallest value, in a set of coins, to stated amount.
III.B
Add value of coin of largest value, in a set of coins to a given amount.
II.A
Determine total value of a set of at least two coins of the same value.
II.B
Rank order a mixed set of coins from smallest to largest value.
I.A
Identify coins according to name: Penny, nickel, dime, quarter, half-dollar.
I.B
Identify individual coins according to value in cents.
I.C.
Identify a numeral which matches a statement of monetary value.

FIGURE 2

Change Making Flowchart



add nickels to various amounts:	5, 10, 15 . . . 85
add dimes to various amounts:	10, 20, 30 . . . 90
	25, 35, 45 . . . 85
add quarters to amounts:	25, 50, 75
add half dollars to 50	
add two-coin combinations:	Half-dollars and dimes
	Dimes and nickels
	Half-dollars and nickels
	Half-dollars and quarters

Every student is tested for each of these sub-skills and receives appropriate amounts of teaching and practice for those which he cannot accomplish. Thus, while every student who is unable to count a set of coins totaling ninety-five cents will be branched into this sequence, each individual will probably follow a somewhat different path in the learning of this particular set of sub-skills.

The entire script for the course is recorded in both English and Spanish, thereby resulting in two unique features of CAI as it was developed at The University of Texas: (1) instruction can be accomplished without the prerequisite of student literacy, and (2) instruction can be accomplished in the language which is most comfortable and useful to the individual student. The course has been programmed so that at any time a student desires, he can have a question or comment repeated in the alternate language. He will then continue in that language until he requests another language change. Each student begins the course in whichever language he prefers.

Components of the Computer Terminal

Every student taking the course sits at the computer terminal, which consists of a keyboard and cathode ray screen, an audio unit

with earphones attached, and a film strip projector and screen. The keyboard has buttons labeled "Yes," "No," "?," and "L" (language ch) and one button for each coin.

A proctor starts the student in the course by "signing-on" using the student's unique number. The proctor specifies the student's sex, since the visual components of the program are different for boys and girls and he also specifies the student's language preference. The student then puts on the earphones and the program begins:

> Hello, I am a machine. I want to play a game with you. First, let me tell you a little about myself. I don't have any ears, so I can't hear you. That means that when you want to talk to me, you have to press the buttons that you see in front of you. There are a lot of buttons in front of you. There are two buttons in front of you which say "Yes" and "No." Press the button with "Yes" on it.

Or, if Spanish has been indicated as the initial language preference, the student hears:

> Hello, yo soy una màquina. Quiero jugar un juego contigo. Para que me conoscas mejor, dejame decirte algo de mi. Yo no tengo orejas, asi que no puedo oir si me hablas. Si me quieres decir algo tienes que empujar uno de los botones en la maquina. En los botones hay uno que dice "Yes" y otro que dice "No." Empuja el boton que dice "Yes."

Progress of One Student

One of the initial students began in English and has completed part of the course. She was able to identify each coin according to its name and its value when asked questions such as:

> "Find the button with the quarter on it. Press the quarter."
> "Now press the coin worth twenty-five cents."

She was not able to rank order an initial set of coins according to value (a half-dollar, two quarters, and three nickels) - so she branched to a series of questions focusing on specific coin combinations. She had no difficulty with combinations of two coins

except the nickel and the dime, so she practiced identifying the largest, nickel or dime, several times. Later when the nickel and the dime were included as two of three coins with a quarter or a half-dollar, she had no difficulty. She then ordered three sets of coins satisfactorily.

Next the course went as follows:

Course: Now I want you to meet someone.
(Close-up photo of a girl is shown.)

C: This is a picture of Linda. Linda is going shopping today. She is going shopping and has asked if you would like to go with her. Would you like to go?

(Student pressed "Yes.")

(Photo of a girl walking in front of a store.)

C: Good. You and Linda have now been window shopping for awhile and now she sees a store that she wants to go into.

(Photo of a girl entering door of store.)

C: You go into the store, but before shopping Linda wants to check and be sure exactly how much money she has with her.

(Photo of a girl opening her purse.)

C: She will be able to know which things she can buy and which things she cannot buy.

(Photo of a hand holding several coins.)

C: As you can see, she has a handful of money. She counts the money by counting the coin worth the most first.

(The coins are counted as each coin is picked up and moved, beginning with the coin of largest value. The student observes this.)

(Photo of coins totaling 95¢ - two quarters, three dimes, and three nickels - ordered in array.)

C: Here is a picture of some money. Count it. When you finish counting it, press the "End" button.

(Student presses "L".)

C: Aqui hay un retrato de dinero. Cuenta el dinero. Cuando acabes de contar, empuja el boton que dice "END".

(Student presses "END".)

(Four numerals and a question mark appear on the cathode ray tube directly above the keyboard.)

C: Has contado el dinero en el retrato. Mira el "screen" y halla un numero que es lo mismo que el dinero que has contado en total. Toca este numero con la pluma de luz. Si no puedes encontrar el numero correcto empuja el boton con la marca de pregunta.

(Student touches "80".)

C: Vamos a ver ahora otros coins.

(Photograph of a nickel--for all tasks requiring the students to count money, she selects her answer from four numbers. She may touch the question marked for help at anytime.)

C: Aqui hay un retrato de dinero. Cuent el dinero. Cuanto es en total? Busca el numero correcto en el "screen" y tocalo con la pluma de luz.

(Student presses "L".)

C: Here is a picture of some money. Count the money. How much is it? Find the correct answer on the screen and touch it with the light pen.

(Student touches "5".)

C: Right! You answer five cents.

C: Now make believe that you are counting money. You have just counted five. And next you have the coins in the picture. How much money altogether?

(Student touches "10.)

C: Right! You answer ten cents.

C: Now make believe that you are counting money. You have just counted thirty-five. How much money altogether?

(Student touches "40".)

C: Right. You answer forty cents.

(Photo of two nickels.)

C: Here is a picture of some money. Count the money. How much is it? Find the correct answer on the screen and touch it with the light pen.

(Student touches "10".)

C: Right. You answer ten cents.

C: Now make believe that you are counting money. You have just counted ten. How much money altogether?

(Student touches "20".)

C: Right. You answer twenty cents.

C: Now make believe that you are counting money. You have just counted fifty-five. How much money altogether?

(Student touches "65".)

C: Right. You answer sixty-five cents.

(Photo of a dime.)

C: Here is a picture of some money. Count the money. How much is it? Find the correct answer on the screen and touch it with the light pen.

(Student touches "10".)

C: Right. You answer ten cents.

C: Now make believe that you are counting money. You have just counted ten. How much money altogether?

(Student touches "20".)

C: Right. You answer twenty cents.

C: Now make believe that you are counting money. You have just counted [illegible]ty-five. How much money altogether?

(Student touches "30".)

C: [illegible] answer thirty cents. NO. You just counted twenty-five. And next you have a dime. How much money altogether?

(Student touches "35".)

C: Right! You answer thirty-five cents.

C: Now make believe that you are counting money. You have just counted forty-five. How much money altogether?

(Student touches "35".)

C: You answer thirty-five cents. NO. You have just counted forty-five. And next you have a dime. How much money altogether? Touch the correct answer now.

(Student touches"?".)

C: You need some help. Very well, I'm glad you asked for help. Make believe that you are counting money. We cannot see the money that you have already counted, but you have just counted twenty-five, thirty-five and next is a dime. Thirty-five cents and a dime is forty-five cents. Touch the correct answer now.

(Student touches "45".)

C: Right! You answer forty-five cents.

C: Now make believe that you are counting money. You have just counted fifty-five. How much money altogether?

(Student touches "45".)

C: You answer forty-five cents. NO. You have just counted twenty-five, thirty-five, forty-five, fifty-five and next you have a dime. How much money altogether? Touch the correct answer now.

(Student touches "60".)

C: You answer sixty cents. (Same response as previous.)

(Student touches "65".)

C: Right! You answer sixty-five cents.

(Since she made several errors here, she goes back to where she bagan having difficulty.)

C: Now make believe that you are counting money. You have just counted twenty-five. How much money altogether?

(Student does not respond in time.)

C: Touch the correct answer now. If you are not sure or would like some help, touch the question mark.

(Student touches "35".)

C: Right! You answer thirty-five cents.

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The student continues with the pictures of two dimes and five dimes, adding each set to various starting amounts. She continued to learn to count sets of coins, until she returned to the set of two quarters, three dimes, and three nickels and counted them correctly, thereby indicating that she had learned the behaviors specified in Objective III.B and is ready to move to Objective IV.B.4 (Figure 2).

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